sciendo

Bulletin of Geography. Socio-economic Series, No. 52 (2021): 95–109
http://doi.org/10.2478/bog-2021-0016

ISSN 1732–4254 quarterly

BULLETIN OF GEOGRAPHY. SOCIO–ECONOMIC SERIES

journal homepages:
https://content.sciendo.com/view/journals/bog/bog-overview.xml
http://apcz.umk.pl/czasopisma/index.php/BGSS/index

The smart city concept in Poland and Ukraine: in search of cooperation opportunities

Roman Lozynskyy[1, CDMR], Viktoriya Pantyley[2, CDMFR], Anna Sawicka[3, CDMFR]

[1]*Ivan Franko National University of Lviv,* Faculty of Geography, Department of Geography of Ukraine, Doroshenko Str, 41, 79-007 Lviv, Ukraine, e-mail: roman.lozynskyy@lnu.edu.ua, https://orcid.org/0000-0001-5435-7636, [2]*Mariza Curie-Skłodowska University,* Institute of Socio-Economic Geography and Spatial Management, Department of Socio-Economic Geography, Kraśnicka Str, 2d, 20-718 Lublin, Poland , e-mail: wiktoria.pantylej@poczta.umcs.lublin.pl, https://orcid.org/0000-0002-7340-292X [3]*Maria Curie-Skłodowska University*, Institute of Socio-Economic Geography and Spatial Management, Department of Spatial Policy and Planning, Kraśnicka Str, 2d, 20-718 Lublin, Poland, e-mail: anna.sawicka@umcs.pl, https://orcid.org/0000-0001-9969-2702

How to cite:
Lozynskyy, R. Pantyley, V. and Sawicka, A. (2021). The smart city concept in Poland and Ukraine: in search of cooperation opportunities. *Bulletin of Geography. Socio-economic Series*, 52(52): 95-109. DOI: http://doi.org/10.2478/bog-2021-0016

Abstract. The article addresses the smart city concept in reference to two neighbouring countries – Poland and Ukraine. The paper also analyses various research trends in the scope of the smart city concept, as well as the process and conditions of the concept's implementation in the studied countries. The detailed analysis covered the implementation of the smart city concept in two cities in Poland and Ukraine belonging to neighbouring second-order administrative units, namely Lublin and Lviv. It was determined that both in Poland and Ukraine, the smart city concept is at its initial stage of implementation. This results from a number of different conditions, primarily including the socio-economic transformation of the countries, and inconsistency in reforming different spheres of socio-economic life in Ukraine. Local initiatives (analysed in detail based on the example of the cities of Lublin and Lviv) were determined to be of key importance in the implementation process.

Article details:
Received: 19 August 2020
Revised: 15 October 2020
Accepted: 22 February 2021

Key words:
smart city,
Poland,
Ukraine,
Lublin,
Lviv

Contents:

1. Introduction

"Smart city" is one of the most popular concepts in modern urban planning – it complements the concept of sustainable development that for years has been the leading research ideology and a target for societal development. In recent years, the smart city concept has gained global character. It has therefore become an increasingly important object of interest among scientists, practitioners and the business sector. One of the basic aspects of the smart city concept is the comparative analysis of the instruments of its implementation and the most important achievements in countries of differing levels of socio-economic development. As a result of such comparison, economically weaker countries are provided with reliable examples of successive development of smart city technologies. More developed countries can become familiarised with interesting and original practices of implementation of the smart city concept applied in less developed countries in conditions of limited financial resources and social and political uncertainty. Poland and Ukraine are two neighbouring countries that exhibited a similar socio-economic situation in the early 1990s, although they chose completely different development paths. After a difficult initial period of transformations, Poland achieved considerable success in reforming different spheres of its socio-economic life, and joined the EU in 2004. Ukraine is still at the stage of slow socio-economic transformation, delayed by the latent conflict with Russia since 2014. Considering the direct vicinity of Poland and Ukraine, building international socio-political relations based on the rules of strategic partnership, as well as strong economic bonds between the countries, it appears justified to conduct a comparison of the implementation of the smart city concept in both countries in terms of instruments for implementing the concept, as well as the problems and successes of selected cities.

The purpose of this article is a comparative analysis of the most important achievements and challenges in implementing smart city technologies in Ukraine and Poland in the context of the search for directions for their potential cooperation.

2. The smart city concept: theoretical and methodological basics of the study

The concept of the smart city first appeared in scientific publications in the USA in the 1990s, and was related to the theory of smart growth (Rosati and Conti, 2016). Its rapid development and implementation in the sphere of policy and planning at the city level, however, has been only recorded since 2010 (Ahvenniemi et al., 2017; Masik and Studzińska, 2018).

The literature provides many different definitions of a smart city. A number of terms related to the smart city also function nowadays, such as "intelligent city", "knowledge city", "creative city", "digital city", "talented city" (Szymańska, Korolko, 2015; Zakrzewska-Półtorak, 2016: 284), as well as "connected city", "entrepreneurial city", "liveable city", or "pioneer city" (Lombardi et al., 2012). According to the researchers Cavada, Hunt and Rogers (2014), there is:

> *"... ...the necessity for a single 'smart cities' definition that deals with both the physical and digital using shared parameter value(s) that can be adopted and shared amongst different localities and within a range of urban contexts adjusting according to existing city condition(s) and vision(s) setting the paradigm for further innovative research in this area. ..."*.

In response to different approaches to defining smart cities, four research trends have emerged in the scope of the concept: restrictive, reflective, rationalistic and pragmatic (Kummitha and Crutzen, 2017; Masik and Studzińska, 2018). The first approach is primarily aimed at the development of advanced IT and ICT technologies. These technologies

are the key instrument stimulating interactions between different participants in socio-economic life, as well as the driving force transforming cities into smart cities (Calzada and Cobo, 2015; Pilarczyk and Górka, 2018). This methodological approach, however, has met a lot of criticism. It assumes a negligible participation of society in determining directions of development, thus potentially intensifying social polarisation. According to the reflective approach, society and human resources in the context of human and social capital are the driving force leading to the development of a smart city (Angelidou, 2015). The role of technology in the development of smart cities is still very substantial, and social issues are of less importance. As emphasised by Masik and Studzińska (2018: 561), the benefits of technology and IT and ICT solutions primarily depend on people's ability to properly apply these technologies to social objectives. The rationalistic approach combines the two aforementioned approaches, and emphasises the development of local communities that should be the main drivers of change (Neirotti et al., 2014). According to Masik and Studzińska (2018: 561), the key aspects of development of a smart city include improving the quality of human capital, and society's ability to use technology. The approach also emphasises the role of smart society in the development of smart cities. Smart society in such a context is society able to develop advanced technological solutions used in everyday life. The fourth approach is the critical one. It assumes that neither advanced technologies nor a high level of human and social capital are the driving force of activities of local authorities. According to the approach, smart cities should be discussed in the organisational–administrative context. As emphasised by the researchers Kummitha and Crutzen (2017), the key problem to solve is the occurring changes in urban regimes towards forms of management based on large corporations.

Different methodological approaches exist regarding the designation of the components of smart cities. The most universal synthetic approach is the designation of six components, including smart economy, smart environment, smart people, smart living, smart mobility and smart governance.

As stated in the article by Huovila, Bosch and Airaksinen (2019: 141), the concept of "smart cities" has been widely criticised for its techno-centric approach and insufficient attention to the population's needs, as well as insignificant contribution to sustainable development. The role and place of the concept of sustainability in smart city definitions was summarised by Toli and Murtagh (2020). The authors analysed 43 definitions of the smart city provided in the literature, and divided them into two categories: sustainability-oriented and non-sustainability-oriented. They found that sustainability-oriented definitions focus on combining soft capital (such as human and social capital) and hard capital (a city's physical infrastructure) to deliver a sustainable, liveable and efficient city. Non-sustain-

Table 1. Indicators stipulated in standards and recommendations for Smart City development (%)

Indicator	*ISO 37120*	*ISO 37122*	*ETSI*	*ITU 4901*	*ITU 4902*	*ITU 4903*	*UN SDG 11+*
Natural environment	9	1	12	0	15	7	7
Built environment	12	9	9	1	2	3	3
Water and waste	18	15	9	6	13	13	13
Transport	7	10	11	5	7	11	11
Energy	6	8	4	2	8	5	5
Economy	16	5	16	4	20	8	8
Education, culture, innovation & science	8	8	9	4	5	14	14
Health, well-being & safety	28	8	9	14	18	21	21
Governance and citizen engagement	3	5	16	9	2	4	4
ICT	2	32	6	54	10	14	14
Sustainability	**89**	**36**	**63**	**22**	**73**	**67**	**87**
Smartness	**11**	**64**	**37**	**78**	**27**	**33**	**13**

Source: based on Huovila, Bosch, Airaksenin 2019: 147–148

ability-oriented definitions highlight the importance of using ICT to efficiently combine resources that would make the city more interconnected, intelligent and liveable (Toli and Murtagh, 2020).

Recent discussions on the subject in the academic environment resulted in the development of a new concept of "smart sustainable cities" (Yigitcanlar and Kamruzzaman, 2018). As of today, the commonly used definition of smart sustainable cities developed by UNECE (United Nations Economic Commission for Europe) and ITU is as follows:

> *"A smart sustainable city is an innovative city that uses information and communication technologies (ICTs) and other means to improve quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social and environmental aspects. (ITU, 2016)".*

A large variety of indicator frameworks and tools exist to assess either the sustainability or smartness of a city.

Many standards and recommendations related to smart city development have appeared in recent years, including a large variety of indicator frameworks and tools (Table 1). Their content shows significant differences due to their different purpose. *ISO 37120, ETSI, ITU 4902, ITU 4903* and *UN SDG 11+* are primarily focused on achieving sustainable development goals in cities and communities. Among them, *ISO 37120* has the lowest number of smart city indicators, and often refers to digital transformation of the city, while *ISO 37122* and *ITU 4901* are strictly connected with ICT implementation in cities.

The *ITU 4904* standard elaborated in 2019 by the International Telecommunication Union is the most advanced in this aspect. Unlike the standards described above, it provides no direct description of indicators. *ITU 4904* identifies five stages of the maturity of smart sustainable cities that are allocated with the purposes distributed around these stages.

The selection of the most appropriate indicators depends on many factors, such as phase of city development (planning, operation), spatial scale (district, city, region, country), time scale of evaluation (real-time to annual), and purpose of assessment (target setting, monitoring, official reporting, self or cross-city benchmarking, marketing) (Huovila, Tuominen and Airaksinen, 2017).

In Poland, research on the issue of smart cities in recent years has been primarily done by economists (for example: Wiśniewski, 2013; Szymańska, Korolko, 2015; Czupis, Ignasiak-Szulc and Kola-Bezka, 2016; Zakrzewska-Półtorak, 2016; Winkowska, Szpilko and Pijeć, 2019), though recently increasingly frequently also by geographers (with particular focus on: Masik and Studzińska, 2018; Pilarczyk and Górka, 2018; Gwozdz, Micek, Sobala-Gwozdz and Świgost, 2019). Among social-economic geographers, Masik and Studzińska (2018) are worth attention. They focused on research on the evolution of the concept, and research trends regarding smart cities. The publication by Gwozdz, Micek, Sobala-Gwozdz and Świgost (2019) concerned a review of indicators regarding the economic condition of Polish cities. According to the aforementioned researchers, the primary research challenges in the context of the smart city concept include: low availability of data referring to the structural dimension, level of innovativeness and financial condition of urban households. Activities aimed at the development of a smart city include, among others, an increase in cooperation and partnership between particular state institutions and local governments and universities, and adopting a uniform methodology for the preparation and processing of data.

In Ukraine, the most important publications concerning smart cities have appeared only over the last five years. The popularity of research regarding smart cities is also confirmed by the number of scientific degrees awarded in the scope. Koperanov (2018) obtained the degree of habilitated doctor in economic sciences, and wrote a scientific monograph concerning research on the methodological basics of management of the development of "sustainable smart cities" in Ukraine. Dmytrenko defended his doctoral dissertation addressing state governance, where he determined e-governance mechanisms at the local level, and published several scientific articles on the subject (Dmytrenko, 2016). Boreiko and Teslyuk conducted research on the information technology of data processing concerning the parameters of public transport passenger flow (Boreiko and Teslyuk, 2016; Boreiko, Teslyuk and Chorna, 2017). More detailed research

on various aspects of the introduction of smart city technologies in Ukraine was conducted by Pozdniakova (2017; 2018; Matyushenko and Pozdnyakova, 2016; Poliakova and Pozdniakova, 2019). Among other publications, research into the implementation of the smart city concept in Ukraine deserves attention. It establishes the patterns and dynamics of the formation of smart cities in the world and in Ukraine (Pavlikha and Kolomechiuk, 2018).

A review of publications concerning smart city issues showed a small number of comparative studies on the implementation of the concept in two or more countries, regions or cities. No such studies exist for Ukraine and Poland. In order to fill this research gap, we first explored the level of implementation of smart city technologies in Poland and Ukraine based on available indicators and rankings, national programmes and strategies, implementation of standards, etc. Then, we determined how the smart city concept is implemented at the local level, based on the case study of Lublin and Lviv. We focused on local development programmes and main areas of implementation of smart city technologies in those cities, and provided examples of best practices. Finally, the study involves a comparative analysis of the achievements and challenges in the scope of implementing the concept in Poland and Ukraine.

3. Implementation of the smart city concept in Poland and Ukraine

The concept of smart cities is still at an early stage of implementation in Poland (Stawasz et al., 2012; Czupich et al., 2016; Sikora-Fernandez, 2018). Cities of Central and Eastern Europe (CEE) show an evidently lower level of integration of systems and innovativeness, as well as an earlier stage and smaller scale of activities than other global and European smart cities (Kola-Bezka et al., 2016). The reason for a slower rate of changes with regard to smart technologies in Polish cities is the socio-economic transformation of the post-socialist country in 1989 (Sikora-Fernandez, 2018). The political transformation offered new opportunities for the development of cities, and Poland's accession to the European Union made financing resources available. In recent years, the "smart city" has become a desirable trend, and a brand for local governments. The idea of smart cities poses new challenges, whereas Poland is still familiarising itself with the fundamental assumptions of developing cities along the idea of sustainable, compact, resilient or connected cities. A closer look at particular activities of cities reveals positive effects of the implementation of smart solutions.

The first symptoms of a change in the approach to development of cities in documents at the national level appeared several years ago. An important document is the national *Strategy of Innovativeness and Efficiency of the Economy Dynamic Poland 2020* (2013), based on the priorities of the *Strategy of Innovativeness of OECD and the EU Strategy Europe 2020*, focusing on investments in ICT technologies, as well as research, development and innovation (R+D+I). In the medium-term *Development Strategy of Country 2020* (2012) and *Long-Term Development Strategy Poland 2030 – the third wave of modernity* (2013), the objectives partially overlap with the assumptions of the concept. The goals of the *National Urban Policy 2023* (2015) also focus on the development of ten zones related to smart cities: spatial management, public participation, transport and urban mobility, low emissions and energy efficiency, revitalisation, investment policy, economic growth, environmental protection and adaptation to climate change, demography, and development of urban areas. The awareness of the need to use ICT, and initial changes in the development policy and spatial policy towards smart cities have been observed in Poland (Czupich et al., 2016). Obstacles currently concern the availability and automation of data (Stawasz et al., 2012; Kola-Bezka et al., 2016; Sojda et al., 2018): access to open-data, data automation; financing difficulties; politicisation of activities; deficit of systemic solutions; low social awareness; marginalisation of environmental problems; growing social inequalities; focus on technology at the cost of quality of living conditions. The European database Eurostat – Urban Audit currently includes 69 Polish cities. The range of variability of indicators available for Polish cities varies from eight to 158 (Sojda et al., 2018). The problem of the availability, quality, processing, and lack of automation and standardisation of data for Polish cities is contrib-

uting to the delay and difficulty in monitoring the progressing changes. A significant step forward in 2015 was the introduction by the Polish Normalisation Committee of the norm **PN-ISO 37120:2015-03** – *Sustainable social development – Indicators of urban services and quality of life, aimed at supporting local governments in the management, planning, and assessment of undertaken activities*. The norm permits the measurement of the effects of management of urban services and quality of life, comparison of the efficiency of activities, and exchange of experiences based on 96 indicators.

According to the ranking European Smart Cities Ranking 4.0 (2015) that includes larger cities with a population from 300,000 to 1 million, Polish cities are below the European average in terms of the assessment index (Pichlak, 2018). In the ranking of medium-sized European cities (2007, 2013 and 2014), 586 cities with a population between 100,000 and 500,000 were classified in the category. It placed Rzeszów, Szczecin, Bydgoszcz, Białystok, Kielce and Suwałki at positions ranging from 48th to 70th.

According to ranking Smart City Index (IMD Business School, 2020), Warsaw takes 55th place, and Kraków 58th place out of a total of 109 cities evaluated by 39 indicators. In ranking the Cities in Motion Index (IESE, 2020), considering 101 indicators of assessment of the smartness of cities, Warsaw takes the 54th out of 174 places, whereas it takes a high 8th position in the dimension of governance. Wrocław takes the 88th out of 174 places, whereas it occupies the 2nd regional position in Eastern Europe Top 5 (Table 2). All three aforementioned cities have improved their positions in recent years. The process of implementation of the smart city concept in Poland is still at its initial stage, and a low number of cities have so far implemented particular solutions – only nine out of 37 were classified as showing active initiative (European Parliament, 2014).

The assessment of the level of smartness of Polish cities was involved in the scientific research for the purpose of adjusting indicators and interpreting results to local conditions (Table 3). The *Comprehensive Smart City Index* (CSCI) ranking assesses the level of smartness potential of 16 voivodeship capitals (Sikora-Fernandez, 2018). Another assessment system is the *Comprehensive Ranking Of Polish Cities* (CRPC) that rates 18 cities based on 42

Table 2. Positions of Polish and Ukrainian cities in selected rankings

N	Ranking	Year	Number of cities	Number of indicators	Kyiv	Lviv	Warsaw	Wrocław	Cracow
1	Cities in Motion Index	2020	174	101	115	x	54	88	x
		2019	174	96	111	x	69	95	x
		2018	165	83	113	x	64	x	x
		2017	180	68	119	x	54	95	x
		2016	181	66	143	x	74	94	x
2	Smart City Index	2020	109	39	98	x	55	x	58
		2019	102	15	92	x	61	x	69
3	Global Cities Index	2019	130	27	x	x	55	x	x
		2018	135	27	x	x	54	x	x
		2017	128	28	x	x	58	x	x
		2016	125	27	x	x	55	x	x
4	Innovation Cities Index	2019	500	162	347	470	114	282	252
		2018	500	162	399	468	102	311	306
5	Quality of Living City Ranking	2019	231	39	173	x	82	x	100
6	Sustainable Cities Index	2018	100	49	x	x	54	x	x

Source: IESE, 2016–20; IMD Business School, 2019–20; Kearney, 2016–19; 2thinknow, 2018–19; Mercer, 2019; Arcadis, 2018

indicators by means of the PROMETHEE method (Ogrodnik, 2020).

These two ranking systems show differences in results. The comparative analysis of both ranking systems shows that the selected indicators, type and quality of data, as well as the applied method of converting the factors may give divergent results, and that they can be complementary. Although it is a valuable comparative tool for measuring an increase in urban smartness, they should be treated as an auxiliary tool, and compared with individual qualitative effects locally.

The most important event of the last decade that accelerated the implementation of smart city technologies in Ukraine was the signing of the association agreement between Ukraine and the EU. Obligations undertaken by Ukraine in the scope of the agreement include developing efficient institutional instruments for reforming different spheres of social life.

The economic and political crisis in the country, as well as the latent conflict in the east of the country triggered by Russia's aggression towards Ukraine, worsened the socio-economic situation in the country. The situation began improving only in 2015. The first important event at the national scale related to implementing smart city technology was held this year – the Kyiv Smart City Forum was established. It is an annual undertaking involving the popularisation of smart city technologies and the implementation of innovative solutions. The initial plan involved only presentations and discussion panels, with guest experts from Ukraine and abroad dealing with the issue of smart cities. Beginning in 2017, the Kyiv Smart City Forum also included an award ceremony for the competition Smart Cities Awards Ukraine. Holding the Kyiv Smart City Forum has been possible thanks to the concept of Kyiv Smart City having been elaborated, at the personal initiation of the city president Vitaliy Klychko in 2015. It was preceded by an arrangement with the German company SAP regarding the development of a platform for an open budget in Kyiv, based on the experience of the American city of Boston. Similar programmes had already been implemented by some Ukrainian cities, but with a focus on e-governance.

In 2018, the issue of the development of smart city technology in Ukraine was included for the first time in the national industry programme *Con-*

Table 3. Comparative analysis of two rank systems for smartness of Polish cities

Comprehensive Smart City Index			Comprehensive Ranking Of Polish Cities		
CITY	SCORE	DEVIATION	CITY	SCORE	DEVIATION
1. Warsaw	30.894	---	Warsaw	0.3556	---
2. Wrocław	13.427	---	Wrocław	0.1015	---
3. Opole	10.538	+7	Cracow	0.0973	+4
4. Gdańsk	10.055	---	Gdańsk	0.0818	---
5. Rzeszów	7.540	+3	Lublin	0.0578	+3
6. Katowice	6.386	+8	Białystok	0.0483	+5
7. Cracow	5.444	-4	Poznań	0.0347	+2
8. Lublin	5.319	-3	Rzeszów	0.0095	+3
9. Poznań	-1.742	-2	Olsztyn	-0.0165	+1
10 Olsztyn	-6.108	-1	Opole	-0.0251	-7
11 Białystok	-9.715	-5	Toruń	-0.0442	+2
			Bydgoszcz	-0.0584	
12 Kielce	-9.722	---	Kielce	-0.0588	---
13 Toruń	-12.099	-2	Szczecin	-0.0773	+1
			Gorzów Wlk.	-0.0961	
14 Szczecin	-12.812	-1	Katowice	-0.1010	-8
15 Łódź	-15.198	+1	Zielona Góra	-0.1270	+1
16 Zielona Góra	-20.515	-1	Łódź	-0.1819	-1

Source: based on Sikora-Fernandez, 2018 and Ogrodnik, 2020

cept of development of digital economy and society of Ukraine for the years 2018–2020, and approval of the plan of undertakings towards its implementation. For the purpose of activising the smart city concept, the programme stipulated: developing the national "road chart" and a framework of digital transformation of cities as the basis for the development of different projects at the city level; developing a national platform – a catalogue of smart city concept solutions; harmonising policies and legislation in accordance with EU requirements in terms of development of digital economy, innovation and city governance; introducing international standards of smart city governance (*ISO-37120, ISO-37101*, and others); support in developing innovative ecosystems in Ukrainian cities; and the inclusion of local communities in the process of making decisions at the smart city level.

In 2019, one more event of great important to Ukraine took place – the introduction of international standards for continuous city development, related to smart management and smart administrative solutions. In particularly, the standards *ISO 37100:2016, ISO 37101:2016, ISO 37106:2018* and *ISO 37120:2018* were introduced for the first time.

Already in 2020, the implementation of innovative technologies in the scope of the smart city concept was introduced as a separate issue to one of the basic national programmes – the *National strategy of regional development for the years 2021–2027*.

As a result of the development of initiatives for introducing the smart city concept, Ukrainian cities began appearing in international rankings. In 2019, the capital city of Ukraine – Kyiv – was included in the raking of IMD Smart City Index for the first time. In 2018, Kyiv and Lviv were included in the top ten cities in the world in the cost effectiveness category (5th and 8th position, respectively), according to fDi's Smart Locations of the Future 2019/20 ranking developed by fDi Intelligence (specialist division of The Financial Times). In the years 2020/21, Kyiv occupied 4th position in that category in the group of Major European cities in the fDix TNW Tech Cities of the Future 2020/21 ranking, ahead of European capital cities such as Bucharest, Sofia, Belgrade, Vilnius and Tallin (Singapore tops, 2020).

The designation of the best cities by level of development of smart city technologies began in Ukraine with the introduction of the Smart Cities Ukraine award, in the scope of the Kyiv Smart City Forum. It involved the best cities in different smartness categories being recognised by a commission of experts. Different smart city criteria were taken into consideration in different years. In 2020, there were seven criteria: "Best energy-efficient city", "Best ecological city", "Best smart-safe city", "Best digital city", "Best inclusive city", "Best architectonic city" and "Best mobile city". The winning cities are separately recognised in categories of cities with a population of up to 100,000 and above 100,000 (Kyiv Smart City Forum, 2020).

The geography of the winning cities throughout the years points to certain specificities of implementation of the smart city concept in Ukraine. The city of Lviv was the winner in different categories the highest number of times – five times, Kharkhiv, Ternopil – three times, Drohobych, Kyiv, Teteiv, Mukachevo, Bila Cerkva, Mariupol – two times. Regarding macroregions, cities from the western part of Ukraine won fifteen times, northern Ukraine – eleven times, central – six times, eastern – eight times, and southern – only once.

The best Ukrainian cities in the context of implementation of the smart city concept are also selected by scientists. In 2017, the Internet portal "Platform of development of cities" in the scope of project Smart city analysed five Ukrainian cities: Vinnytsia, Dnipro, Kyiv, Kharkhiv and Chernivtci. A total of 35 indicators from six smart city categories were analysed. The following cities were recognised as best in different categories: "e-governance" – Kyiv and Kharkhiv; "openness of local authorities and transparency of adopting decisions" – Vinnytsia, Dnipro, Lviv; "openly accessible administrative services" – Vinnytsia, Lviv; "municipal zone" – Vinnytsia; "transport" – Kyiv; "health protection and education" – Kyiv and Dnipro; "smart energy" – Lviv; "tourism" – Vinnytsia and Chernivtsi (Smart-innovations, 2017).

In 2019, based on data for 2017 and 2016 and by means of their own methodology, Poliakova and Pozdniakova (2019) calculated the Smart City index for six Ukrainian cities. In the context of their results, the first place was occupied by Kyiv, followed by Lviv, Vinnytsia, Kharkhiv and Dnipro, and Odessa.

Active use of smart city instruments in some cities allowed local authorities to find efficient solutions in the scope of counteracting negative effects of the SARS-CoV-2 pandemic after weakening the quarantine in the country in May 2020. In Kamianets-Podilskyi on 30 April, in particular, in the quarantine period, the tourist season was opened online. A web-forum and virtual trips were organised, as well as prizes for potential tourists being given. Due to this initiative, Kamianets-Podilskyi together with Barcelona and Gdańsk, won the international competition "Good Practices Competition" held in autumn this year as part of the meeting of the Congress of trans-border cooperation "Lublin-2020".

Today, Ukraine is facing the task of adjusting technical regulation relating to standardising smart cities and smart communities to international and European norms. One of the most important related challenges is the insufficient institutional ability of executive authorities to implement the policy of reforming different spheres of social and economic life. Irrespective of the appointment of a Ministry of digital transformation of Ukraine, the development of a uniform national policy of sustainable development of smart communities is not efficient enough. Due to this, many decisions made in Ukraine by cities and local communities are chaotic and based on personal initiatives and individual visions without relevant adjustment to the existing norms or arrangement with other territorial communities. The incoherence is also determined by the political factor – insufficient consistency and determination in carrying decisions through in the event of turnover of city and local community leaders after elections.

4. Smart initiatives at the local level: case study of Lublin and Lviv

Lublin is the largest economic and academic centre in Eastern Poland, with a population of 339,500 inhabitants in the core city, and more than 608,000 inhabitants in the metropolitan area (GUS, 2020). The city of Lublin features nine universities that educate around 63,000 students annually and represent a considerable potential at the international level. Lublin was not included in the official European Smart Cities Ranking of European ranking of medium-sized cities (2007, 2013, 2014) or in the European Smart Cities Ranking 4.0 (2015). The city has been striving to meet standards in recent years by collecting the required data.

In the process of implementing smart cities, local initiatives are of key importance. The current *Development Strategy of Lublin 2020* (2013) stipulates the implementation of a new governance model involving the active participation of residents in developing "a city of the future". The project *Inventing Lublin together. Participatory development of smart strategy Lublin 2030*, implemented in the scope of the ministerial programme *Human Smart Cities. Smart cities co-created by residents and the programme Foresight Lublin 2050*, involved the participation of more than 12,000 people. In 2017 *Foresight Lublin 2050* was implemented. Expert Thematic Research Groups were also established, determining objectives and activities.

A necessary aspect of smart cities is sustainable mobility. The document stipulating the vision of development of transport is the *Sustainable Mobility Plan of Lublin* (2015), corresponding with the objectives of the *European White Paper on Transport* (2011). The SMP of Lublin prioritises the provision of an efficient, economical and safe system of public transport, counteracting negative trends of dependency on the passenger car, obtaining energy efficiency, ergonomics of urban space, and economical management of spatial resources. The SMP recommends the coordination of transport plans and transport solutions with local spatial development plans, and at the project scale the application of qualitative urban planning solutions as the basis for road investments. Properly set priorities, however, do not correspond with the practical solutions for developing a smart and accessible transport network for the city. New facilities and standards were implemented, including 70 trolleybuses and 100 low-emission buses meeting EURO 5 and EEV standards. The service quality and ICT transport solutions are important improvements. The **Dynamic Passenger Information System** allows for real-time tracking of bus location. The solutions also include a paid parking zone in the city core, and Park & Rides. The next target is to build a rapid charging centre for electric buses based on panto-

graph connectors and 450-kW, high-power chargers. Despite these technological solutions, the proposed concentric model of transport service in the city is at variance with the rules of planning of an efficient system of urban mobility. Spatial structure models are currently based on the polycentric system – a network of mutually correlated urban centres providing for efficient organisation and transport service in the urban space. Smart technologies are not able to provide sufficient quality and efficiency if, at the planning and urban design stage, no qualitative conditions are provided. Smart solutions are aimed at facilitating and improving the level of urban mobility services.

The Polish Normalisation Committee granted the city of Lublin the *Certificate of Management of Urban Services and Quality of Life No. PN-100/003/2019-S* (2019) in the scope of methodology for calculating indicators of urban services and quality of life. By providing data for 96 indicators, Lublin obtained the *Attest of Compliance with the Polish Norm – the PN Certificate* for a period of three years. The Smart City Forum granted Lublin with the Smart City Award – ***"Smart City of the Year from 100 to 500 thousand of residents 2015"*** for the implementation of the Traffic Management System – ITS complemented by the **Public Transport Management System** within the scope of the Integrated System of Urban Public Transport System. The installed road-traffic management software efficiently manages traffic by predicting traffic streams and intensity, and simulating situations on the road and the behaviours of drivers. According to the local government, improving traffic flow will also contribute to improving the public transport efficiency and improving air quality. Another project of Lublin rewarded with the *Smart City Award* in 2020 is the implementation of a complex spatial model of the city in the *OGC cityGML* standard. The 3D model is used for monitoring spatial phenomena and 3D analysis, through, among other things, analysis of the solar potential of building development, the spread of noise in a 3D space, and tracing processes of spatial transformations. The project is in line with the legal requirements of *European Directive 2002/49/EC* (2002) regarding the assessment and management of environmental noise, and stipulates many optional functions improving local standards.

The implemented projects have made Lublin an important location for the telecommunication sector in Eastern Poland, and one of six key IT systems in the country. Despite its absence from European rankings, Lublin stands out among Polish cities. The changes have occurred recently, and are considered positive, but the big challenge is the integration of technological improvements in spatial planning and urban design. A smart city will not bring the expected benefits if it is not a sustainable city – these dimensions should be mutually complementary.

The first undertakings in the scope of the smart city concept in Lviv appeared even at the beginning of the 2010's in relation to the city's preparation for EURO-2012. In January 2012, a new system of transport traffic started functioning in the city, developed by French company Luis Berger. Changes in the scope of transport traffic were caused by very dense historical building development (the centre of Lviv is listed as a UNESCO heritage site), leading to constant traffic jams. Another problem of the city was expensive energy carriers purchased by Ukraine in Russia. To solve that problem, the city authorities passed the *Concept of implementation of energy governance,* including undertakings aimed at applying energy-efficient technologies using smart management.

A very important direction in implementing smart city technologies is cooperation between the city's universities. Lviv is among the first three cities in Ukraine in terms of the highest number of students. Another factor in the city's success towards a smart city is its orientation to the development of the IT sector. According to data from the information portal "Lviv IT cluster", more than 25,000 specialists worked in the IT sector in Lviv in 2019, and the sector's contribution to the city's economy was 21%. The third element stimulating smart city development is the tourism sector.

In March 2015 in Lviv, the Lublin Catholic University together with the Lviv Business School and Lviv Municipal Office organised the first workshops for cities, called "Smart City". In autumn 2015, the international "Forum 451°E" was held, addressing the issues of e-governance and the smart city. It became a cyclical event. In 2016, the *Programme of digital transformations of Lviv for the years 2016–2020* was adopted. In the scope of the programme, a separate structure was developed that was includ-

ed in the composition of the Lviv Municipal Office – a section for smart services and connections in management of IT technologies of the department of development. As a result of the section's work, the city's e-governance websites are currently the best in Ukraine.

In 2017, a project for introducing smart city technologies was implemented based on the example of one of the city's districts, entitled *Naukowa – smart microdistrict*. The greatest achievements were recorded in the sphere of education at schools (interactive classrooms, sensory rooms, Montessori rooms). New "intelligent" public spaces were also developed, as well as bus stops, and "intelligent" street lighting was organised.

In 2019, the *Programme of sustainable energy development of the city of Lviv* was adopted, and at the beginning of 2020, the *Plan of continuous urban mobility of the city of Lviv*. At the end of September 2020, implementation of an *ISO 37101:2016* quality management system commenced.

As a result of all undertakings described above, over the last three years, the city of Lviv has won different nominations at the Forum Kyiv Smart City: in 2018 it won in the category "City of Start-ups". In 2019, the transport model of Lviv was recognised as the best in Ukraine. In 2020, the city was distinguished in as many as three categories: "Best ecological city", "Best architectural city" and "Best mobile city".

An important feature of smart city development in Lviv is the significant activity of private companies. They have recently initiated two smart solutions in the city, which are the most frequently mentioned in the press. In 2017, the mobile operator Vodafone introduced a "smart" tourist route in Lviv as part of the national initiative "Vodafone Smart Routes". In 2019, the company Galnaftogaz installed the largest facade solar power station in Western Ukraine at its headquarters in Lviv.

The most serious challenges in implementing smart city projects are economic and political. The first is primarily the lack of resources for more expensive solutions towards a smart city. The second problem is the intense political fight for power at every municipal election. The active introduction of smart city technologies is resisted by some political opponents citing irrational expenditure of city budget resources. Another problem is the imperfection of legal regulation of separate aspects of the implementation of smart city technologies. For example, due to the aforementioned factors, a solar power plant opened on the roof of a public school in 2018 did not commence functioning. The reason was a failure to adjust the normative base at the national level regarding the production of excess energy by a power plant – it turned out that schools cannot sell it.

5. Smart-city in Poland and Ukraine: comparison of achievements and challenges

Differences between Poland and Ukraine in the practical implementation of the smart city concept are not as substantial as in other spheres of their socio-economic life, particularly in terms of the economic condition of both countries, where Poland is in a considerably more comfortable position.

The implementations of the smart city concept in Poland and Ukraine have common and distinctive features due to the influence of external and internal factors (Table 4). Both Poland and Ukraine are at the initial stage of implementing standards in the scope of the smart city concept, although Poland is at a more advanced stage of its implementation due to standards having been approved earlier (four years earlier than in Ukraine) at the national level. A considerable advantage of Poland is its greater opportunities for financing as a result of the higher level national economic development, the larger budgets of territorial communities, and the opportunities to use EU financing sources. This is reflected by higher positions of Polish cities in global and European rankings. Ukraine's advantage is its rapid development of the IT sphere, the increase in employment in the sector in recent years, and the government's orientation towards digitisation of all spheres of social life.

The variable efficiency of implementation of smart solutions in urban policy is primarily determined by initiatives of local authorities. In Poland, the greatest potential towards smart cities is observed for Warsaw, Wroclaw and Cracow. Small-

Table 4. Smart city concept in Poland and Ukraine: comparative analysis

Poland	**Ukraine**
Political status in Europe	
European Union member state (2004)	European Union Association Agreement (2017)
Sectoral programme linked to the smart city concept	
Strategy of Innovativeness and Efficiency of the Economy *Dynamic Poland 2020 (*2013) Strategy for Productivity in Poland 2030 (planned for approval in 2021)	Concept of development of digital economy and society of Ukraine for the years 2018–20, and approval of the plan of undertakings towards its implementation (2018, the document is extended until 2021)
Basis of the sectoral programme	
Strategy of Innovativeness of OECD and the EU Strategy Europe 2020	government initiatives
Connected national programme	
National Urban Policy 2023	National strategy of regional development for the years 2021–27
Priority of activities (according to sectoral programme)	
spatial management, public participation, transport and urban mobility, low emissions and energy efficiency, revitalisation, investment policy, economic growth, environmental protection and adaptation to climate change, demography, and development of urban areas.	modernisation of urban infrastructure and introduction of effective resource management; transformation of the city government system based on the integration of systems and data; determination of economic models of urban development taking into account natural, industrial, and human potential
Basic standard	
PN-ISO 37120:2015-03 – *Sustainable social development – Indicators of urban services and quality of life (2015)*	DSTU ISO 37120:2019 – Sustainable cities and communities. Indicators for city services and quality of life (2019)
Cities with best implementation of smart city technologies	
Warsaw, Cracow, Wroclaw, Gdansk, Lublin	Kyiv, Lviv, Vinnytsia, Kharkiv, Ternopil
Main problems of cities linked to the smart city concept	
air pollution, road congestion, affordable housing, security, fulfilling employment	corruption, road congestion, affordable housing, basic amenities, security
Main problems in the implementation of the smart city concept	
difficulties in financing, deficit of integrated ideas, attempts to politicise the concept, low degree of popularisation	difficulties in financing, corruption in the implementation process, deficit of integrated ideas, low degree of popularisation

Source: compiled by the authors

er regional cities such as Lublin are not far behind, and consequently undertake initiatives to implement smart solutions at a high level. Despite evident successes, the changes are of local character, taking the form of single projects. What are missing are integrated, planned, systematic activities. The example of Lublin shows that the priorities declared in strategic and programming documents are not coherent with the directions of activities. It is important to improve different aspects of the functioning of cities using the new possibilities offered by smart technologies, instead of introducing ICT separately

from a comprehensive vision of the city's development. This requires support for local governments at the national level that has been negligible so far.

In Ukraine, for a relatively long time, local initiatives were the driving force for the introduction of smart city technologies, and the state showed no particular activity in the scope. The greatest successes in terms of implementing the smart city concept concern the capital city of Ukraine – the city of Kyiv. It constitutes a separate second-order administrative–territorial unit, on a par with districts, with a substantially greater city budget stipulated by the legislation in comparison to other cities of Ukraine. Other cities deserving of attention include those in western Ukraine, and particularly Lviv. The successes of these cities are determined not only by their location (in the direct vicinity of the EU countries), facilitating the introduction of innovations, but also by greater orientation at the tourist sector, favouring the implementation of smart city technologies.

Over the coming years, the main driver of the introduction of smart city technologies in Ukraine should be the administrative–territorial reform of the country. A new system of administrative–territorial division was adopted in 2020. The reform is expected to considerably increase the financial capacity of local communities by redistributing taxes in their favour. An important aspect of the development of smart city technologies in Ukraine is also the country's central authorities strivance towards European integration, which has been considerably weaker recently.

National scale challenges in implementing the smart city concept shared by both countries include:

- difficulties in financing;
- deficit of systemic (integrated) ideas and on-site solutions;
- attempts to politicise the concept;
- low degree of popularisation of the benefits of the concept;
- its insufficient connection with the implementation of sustainable development objectives;
- weak connection with the spatial planning system.

At the level of separate cities, the primary problems of both countries' residents that could be solved by smart city technology include problems with urban mobility, safety of residents, and accessibility of quality housing. Cooperation on implementing the smart city concept would also be effective in the sphere of tourism, particularly in Ukraine, where its development is frequently related to the cultural heritage of Ukrainians and Poles. The cooperation of Lublin and Lviv could also be effective in solving the problem of urban mobility by implementing related initiatives in Lviv that have been successfully applied in Lublin. The cooperation can also take advantage of the potential of Lviv as a large centre of higher education and science, and its IT sphere.

6. Conclusions

The future socio-economic and spatial development of cities currently depends on modern technologies offering a broad spectrum of opportunities to create sustainable cities that provide for high quality of life. The implementation of these technologies will be favoured by cooperation between the countries at different territorial levels: national, regional and local.

The main finding of this study is that the successive experience of international cooperation between Poland and Ukraine in various spheres of social life must be supplemented with shared projects implementing the smart city concept. The comparative analysis of the primary achievements and challenges for both of the analysed countries in implementing the smart city concept points to considerable opportunities for cooperation that would be beneficial to residents of both Ukraine and Poland.

The smart city concept is one of the dimensions of development of cities necessary for their future development. Nonetheless, it supplements rather than replaces the fundamental concepts such as "the sustainable city" with new aspects geared towards smart sustainable city or smart inclusive city. Therefore, particular attention is paid to the threats caused by focusing on technology separately from the spatial and social dimension, unadjusted to local conditions.

Our study results can be used by national authorities and self-governments of both countries for the purpose of developing shared projects for implementing the smart city concept. Further re-

search should be directed at detailed investigation of the experiences of selected cities of Ukraine and Poland (successful initiatives by small towns would be particularly interesting in this context). Analysis of the cooperation opportunities by smart city component would also be interesting, particularly in the sphere of e-governance, i.e. where both countries have been largely successful.

References

Ahvenniemi, H., Huovila, A., Pinto-Seppa, I., and Airaksinen, M. (2017). What are the differences between sustainable and smart cities, *Cities*, 60: 234–245.

Angelidou, M. (2015). Smart cities: A conjecture of four forces, *Cities*, 47: 95–106.

Boreiko, O. and Teslyuk, V. (2016). Developing a controller for registering passenger flow of public transport for the "smart" city system, Eastern-European *Journal of Enterprise Technologies*, 2016. 3(84): 40–46. DOI: https://doi.org/10.15587/1729-4061.2016.84143

Boreiko, O., Teslyuk, V., and Chorna, I. (2017). Analysis and prospects of smart city technology development. Innovative education as a constituent part of the smart city, S*eries of monographs Faculty of Architecture, Civil Engineering and Applied Arts Katowice School of Technology*, 14, 60–70.

Calzada, I., and Cobo, C. (2015). Unplugging: Deconstructing the Smart City, *Journal of Urban Technology*, 22(1): 23–43.

Cavada, M., Ch., Rogers, and Hunt D. (2014). Smart Cities: Contradicting Definitions and Unclear Measures, World Sustainability Forum 2014 – Conference Proceeding Paper.

Czupich, M., Kola-Bezka, M., and Ignasiak-Szulc, A. (2016). Factors and barriers of implementation of smart city concept in Poland (in Polish), *Studia Ekonomiczne*, 276: 223–235.

Dmytrenko, V. (2016). Specificities of E-Governance Local Implementation in Ukraine, *Public Policy and Economic Development,* 9(13): 84–93.

European Parliament (2014). Mapping smart cities in the EU.

European Parliament (2002). Directive 2002/49/WE (2002/49/EC) of the European Parliament and of the Council of 25 June 2002 relating to the assessment and management of environmental noise. Available at: https://eur-lex.europa.eu/eli/dir/2002/49/oj (22.02.2021).

Gwozdz, K., Micek, G., Sobala-Gwozdz, A., and Świgost, A. (2019). Review of the Issue of Indicators of the Economic Condition of Cities in Poland (in Polish), *Prace Komisji Przemysłu Polskiego Towarzystwa Geograficznego*, 33(2): 59–80.

Huovila, A., Bosch, P., and Airaksinen, M. (2019). Comparative analysis of standardized indicators for Smart sustainable cities: What indicators and standards to use and when? *Cities*, 89: 141–153.

Huovila, A., Tuominen, P., and Airaksinen, M. (2017). Effects of building occupancy on indicators of energy efficiency. *Energies*, 10(5): 628. DOI: https://doi.org/10.3390/en10050628

ITU (2016). Recommendation ITU-T Y.4900. Available at: https://www.itu.int/itu-t/recommendations/rec.aspx?rec=12627&lang=en (28.01.2021)

Kola-Bezka, M., Czupich, M., and Ignasiak-Szulc, A. (2016). Smart cities in Central and Eastern Europe: viable future or unfulfi lled dream? *Journal of International Studies*, 9(1).

Korepanov, O. (2018). Methodological bases of statistical support of management of development of "smart" sustainable cities in Ukraine. Kyiv.

Kummitha, R.K.R., and Crutzen N. (2017). How do we understand smart cities? An evolutionary perspective, *Cities*, 67: 43–52.

Kyiv Smart City Forum (2020). Available at: https://forum.kyivsmartcity.com (13.11.2020).

Lombardi, P., Giordano, S., Farouh, H., and Yousef, W. (2012). Modelling the smart city performance. Innovation: The European *Journal of Social Science Research*, 25(2): 137–149.

Long-term Development Strategy of Poland 2030 – The third wave of modernity (2013), Ministry of Administration and Digitization.

Masik, G., and Studzińska D. (2018). Evolution of the Smart City concept and of research into it (in Polish), *Przegląd Geograficzny,* 90(4): 557–571.

Matyushenko, I. and Pozdnyakova, A. (2016). Smart Cities in Ukraine – the evolution, state and challenges of smart solutions in the area of governance, *Acta Innovations*, 19: 25–36.

National Development Strategy 2020 (2012), Ministry of Regional Development.

National Urban Policy 2023 (2015), Ministry of Infrastructure and Development.

Neirotti, P., De Marco, A., Cagliano, A.C., Mangano, G., and Scorrano, F. (2014). Current trends in Smart City initiatives: Some stylised facts, *Cities*, 38: 25–36.

Ogrodnik, K. (2020). Multi-criteria analysis of smart cities in Poland. *Geographia Polonica*, 93(2): 163–181.

Pavlikha, N. and Kolomechiuk, V. (2018). Patterns and dynamics of the Formation of smart cities in the world and in Ukraine, *Ekonomichnyi chasopys Skhidnoievropeiskoho natsionalnoho universytetu imeni Lesi Ukrainky,* 2: 42–47. DOI: https://doi.org/10.29038/2411-4014-2018-02-42-47

Pichlak, M. (2018). Smart cities in Poland – reality or utopia? *Zeszyty Naukowe. Organizacja i Zarządzanie/ Politechnika Śląska.*

Pilarczyk, A., and Górka, K. (2018). Lublin as a smart city (In Polish), In Maleszyk, P. and Sagan, M. editors, Lublin 2030 – europejska metropolia? Lublin: Urząd miasta Lublin, 147–159.

PN-ISO 37120:2015-03 – Sustainable social development – Indicators of urban services and quality of life (2015), Polish Normalisation Committee.

Poliakova, O., and Pozdniakova, A. (2019). A methodological approach to evaluating the progress of the implementation of the smart city concept in Ukrainian cities, *Problemy ekonomiky*, 1 (39): 73–82.

Pozdniakova, A. (2017). Digitalization process in Ukraine as a prerequisite for the smart city concept development. Baltic *Journal of Economic Studies*, 3(4): 206–215.

Pozdniakova, A. (2018). Smart city strategies "London-Stockholm-Vienna-Kyiv": in search of common ground and best practices, *Acta Innovations*, 27: 31–45.

Rosati, U., Conti, S. (2016). What is a smart city project? An urban model or a corporate business plan? *Procedia-Social and Behavioral Sciences*, 223: 968–973.

Sikora-Fernandez, D. (2018). Smarter cities in post-socialist country: Example of Poland. *Cities,* 78: 52–59.

Singapore tops (2020). Singapore tops fDi's Smart Locations of the Future 2019/20 ranking. Available at: https://www.fdiintelligence.com/article/74562 (13.11.2020).

Smart cities. Ranking of European medium-sized cities (2007). Final report – October 2007. Available at: http://www.smart-cities.eu/download/smart_cities_final_report.pdf (10.11.2020).

Smart-innovations (2017). Smart-innovations of Ukrainian cities. Urban development platform. Available at: http://www.urbanua.org/dosvid/ukrayinski-prykladdy/340 (13.11.2020).

Sojda, A., Owczarek, T., and Wolny, M. (2018). Smart City in data-oriented approach – Poland in the Eurostate database. *Zeszyty Naukowe. Organizacja i Zarządzanie/Politechnika Śląska.*

Stawasz, D., Sikora-Fernandez, D., and Turała, M. (2012). Smart City concept as a determinant of making decisions related to the functioning and development of the city. *Zeszyty Naukowe Uniwersytetu Szczecińskiego*, 721(29): 97–109.

Strategy of Innovation and Economic Efficiency Dynamic Poland 2020 (2013), Ministry of Economy.

Sustainable Mobility Plan of Lublin (2015). The City of Lublin.

Szymańska, D., Korolko, M. (2015) Inteligentne miasta - idea, koncepcje i wdrożenia (Smart Cities - ideas, conceptions, and implementation - in Polish), Wydawnictwo Naukowe Uniwersytetu Mikołaja Kopernika w Toruniu, p.164. DOI: http://repozytorium.umk.pl/handle/item/5550.

Toli A. M. and Murtagh N. (2020). The Concept of Sustainability in Smart City Definitions. Front. *Built Environ*. 6:77. DOI: 10.3389/fbuil.2020.00077

Winkowska, J., Szpilko, D., and Pejić, S. (2019). Smart city concept in the light of the literature review, *Engineering Management in Production and Services*, 11(2): 70–86.

Wiśniewski, M. (2013). Smart cities – definicje i pomiar (przegląd koncepcji), *Prace Naukowe WWSZiP*, 24(4): 187–199.

Yigitcanlar, T., and Kamruzzaman, M. (2018). Does smart city policy lead to sustainability of cities? *Land Use Policy*, 73: 49–58. DOI: https://doi.org/10.1016/j.landusepol.2018.01.034

Zakrzewska-Półtorak, A. (2016). Smart city – is it a catalyst for regional development? (in Polish) Prace Naukowe Uniwersytetu Ekonomicznego we Wrocławiu, 443: 283–291.